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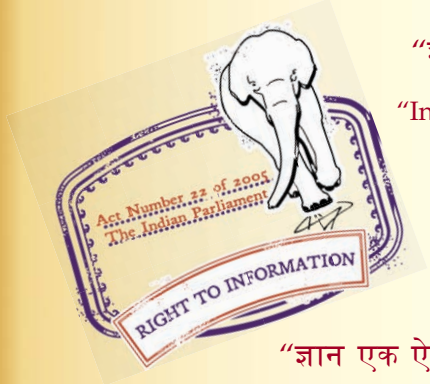

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RECOMMENDED PRACTICE FOR FLASH BUTT WELDING OF TUBES, RODS AND OTHER SECTIONS IN CARBON AND ALLOY STEELS

UDC 621·791·762·5 : 621·643·2 [669·14]

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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November 1987

Indian Standard

RECOMMENDED PRACTICE FOR FLASH BUTT WELDING OF TUBES, RODS AND OTHER SECTIONS IN CARBON AND ALLOY STEELS

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Indian Standard

RECOMMENDED PRACTICE FOR FLASH BUTT WELDING OF TUBES, RODS AND OTHER SECTIONS IN CARBON AND ALLOY STEELS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 7 October 1986, after the draft finalized by the Welding General Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 This standard is intended to serve as a guide in the flash butt welding of steel components.

0.3 This standard keeps in view the practices prevailing in the country in this field. Assistance has also been derived from the following publications:

BS 4204 : 198 1 Specification for flash welding of steel tubes for pressure applications. British Standards Institution.

IIS/IIW : Doc : 111-562-1977 Recommended tests for resistance and friction welds. International Institute of Welding.

IIS/IIW : Doc : 111-588-1978 Amendment to Doc : 111-562-1977. International Institute of Welding.

IIS/IIW : Doc : 111-650-1980 Testing of flash welding boiler tubes. International Institute of Welding.

Resistance welding manual vol I-l 969 published by Resistance Welder Manufactures' Association (RWMA), Philadelphia, USA.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Rules for rounding off numerical values (revised).

1. SCOPE

1.1 This standard specifies the general requirements for the automatic flash welding of joints between steel bars, solid sections, pipes and tubes, for general as well as pressure and other high duty applications.

NOTE — Details regarding the machinery required, the parameters to be chosen, etc, are given in Appendices A and B.

2. TERMINOLOGY

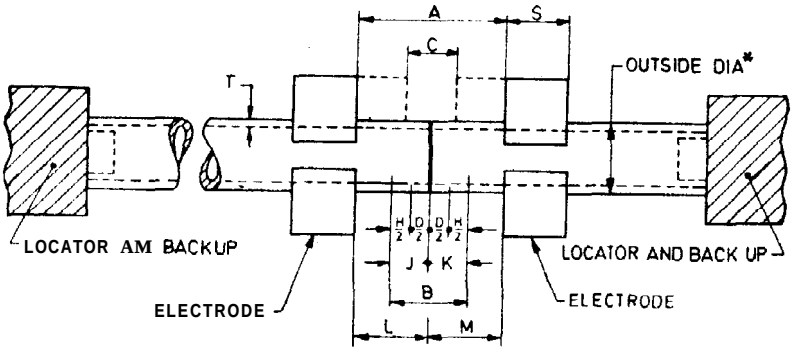
2.1 For the purpose of this standard the definitions as given in IS : 812-l 957* and those given in **2.1.1** to **2.1.25** shall apply.

2.1.1 ***Clamping Force*** — The force exerted on the jaws by the clamping system.

2.1.2 ***Final Electrode (Die) Opening*** — Distance between electrodes at the completion of weld which depends upon the shape and size of the sections to be welded and the condition of the end faces (see 'C' in Fig. 1 and 2).

2.1.3 ***Flash*** — The material that is thrown and expelled from weld line during flashing and upsetting operations.

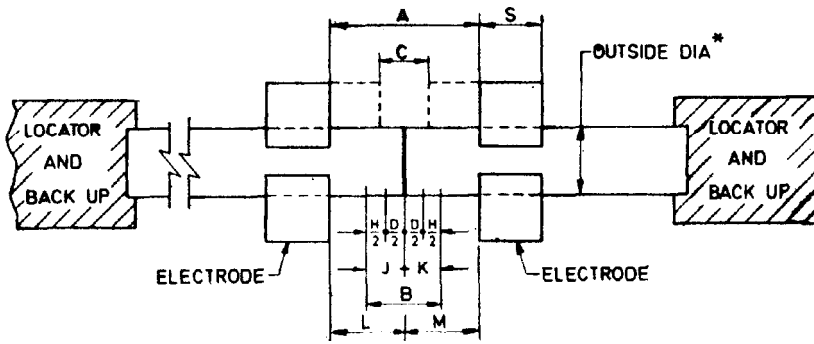
2.1.4 ***Flashing Current*** -- The current that flows through the workpieces during flashing.



T = tube wall or sheet thickness
A = initial die opening
B = material lost
C = final die opening
D = total flash off
H = total upset
$J = K$ = material lost per piece
$L = M$ = initial extension per piece
S = minimum necessary length of electrode contact
*OD = outside dia of tubing

FIG. 1 FLASH BUTT WELDING OF TUBING AND FLAT SHEETS

*Glossary of terms relating to welding and cutting of metals.



A = initial die opening
B = material lost
C = final die opening
D total flash off
H = total upset
$J = K$ = material lost per piece
$L = M$ = initial extension per piece
S = minimum necessary length of electrode contact
$*OD$ = diameter of rounds or minimum dimensions of other section

FIG. 2 FLASH BUTT WELDING OF SOLID SECTIONS

2.1.5 *Flashing Time* — The period between the start of continuous flashing and the time when upset force is applied.

2.1.6 *Initial Electrode Opening or Total Overhang* — Distance between the electrodes when the workpieces first contact which depends on the shape and size of the section to be welded and the condition of the end faces (see 'A' in Fig. 1 and 2).

2.1.7 *Material Lost* — The total length of material used in making the weld (see '*B*' in Fig. 1 and 2).

2.1.8 *Material X Lost* — Length (*see* '*J*' in Fig. 1 and 2) of the material X used in making the weld.

2.1.9 *Material Y Lost* — Length (*see* '*K*' in Fig. 1 and 2) of the material Y used in making the weld.

2.1.10 *Overhang Material X* — The distance (see '*L*' in Fig. 1 and 2) from the electrode that clamps material X to the point on material X that first contacts material Y.

2.1.11 *Overhung Material Y* — The distances (see '*M*' in Fig. 1 and 2) from theelectrode that clamps material Y to the point on material Y that first contacts material X.

2.1.12 *Post-Heating Current* — The current that flows through the workpieces during post-heating.

2.1.13 *Post-heating Time* — The time during which post-heating takes place.

2.1.14 *Prc heating Current* — The current that flows through the work. pieces during flashing.

2.1.15 *Pre-heating Time* -- The time during which pre-heating takes place.

2.1.16 *Secondary Volt* — It is open circuit voltage of welding transformer measured on secondary **side.**

2.1.17 *Total Flash Off* — Total length of material lost in flashing.

2.1.18 *Total Upset* — Length of material lost due to forging action.

2.1.19 *Upsetting Current* -- The current that flows through the workpieces during upsetting.

2.1.20 *Upsetting Current Time* — The time during which upsetting current flows.

2.1.21 *Upsetting Force* — The force exerted at the welding surfaces during upsetting.

2.1.22 *Upsetting Time* — The time during which upsetting takes place.

2.1.23 *Weld Line* — The plane of solid phase bending of welded work-pieces.

2.1.24 *Welding Period* — The time that elapses from the start of pre-heating time to and of clamp holding time.

2.1.25 *Welding Time* — The time during which flashing and upsetting takes place.

3. PARENT METAL

3.1 It shall be determined by the procedure qualification tests (see 14) that the steel or combination of steel can be satisfactorily welded by flash butt welding process.

4. SIZES

4.1 The sectional area, and shape and size of the components that can be welded by flash butt welding depends on the capacity (electrical and hydraulic/pneumatic load generation) and the design of the machine. Particular care should be taken when welding hollow sections with regard to its slenderness ratio for a given clamping length between clamps and the required upsetting pressure.

5. BACKING GASES

5.1 Backing gases are used to minimize flash and oxidation in the bore of the tube by flowing away the flash during the process. The various backing gases that may be used are dry air, argon, formier gas (10 percent H_2 + 90 percent N_2) or any other suitablegas mixture.

The. type of the backing gas and pressure at which it is to function is dependent on the type of material to be welded and the dimensions of the tube. The gas to be used and pressure at which it is to be supplied shall be determined while fixing the welding procedure. The flow should be so adjusted as to provide a positive pressure at the weld.

It is considered to be good practice to use dry air for carbon steel tubes and argon or other gas mixtures for low alloy and austenitic steels. It is essential, when gases other than air is used as backing gas, the gases should be present throughout the pre-heating and cooling cycle and, therefore, an adequate purge time should be allowed for the gas to completely fill the tube and tube shall remain completely filled until the weld has cooled, or tube has been withdrawn from the machine. When long lengths of tubes are being welded, internal purging devices (diaphragms) can be used to reduce consumption of backing gas. If air is used as backing gas, the flow is stopped after the upsetting operation is over.

5.2 No backing gas is required for welding solid sections.

6. PREPARATION AND MATCHING OF ENDS

6.1 The end of each tube to be welded shall be machined to make the section at right angles to the axis of the tube as shown in Fig. 3A.

To facilitate the onset of flashing in higher sectional areas, one of the component or both may be chamfered as shown in Fig. 3B.

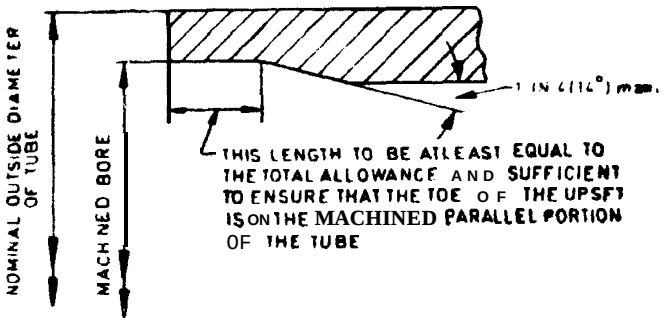
When each tube has to be machined. boring shall be concentric with the outside diameter of the tube, care being taken that the tube thickness is not reduced below the specified design thickness. The machining shall run out smoothly into the bore at a taper not steeper than 1 in 4.

6.2 The contact areas, while welding the solid sections, should be made equal to the extent possible.

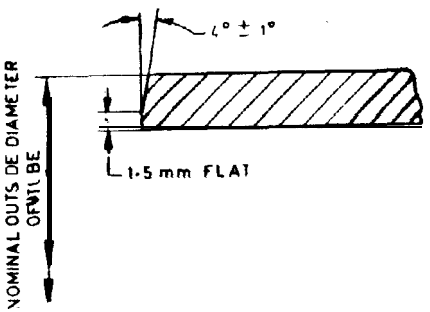
To facilitate the flashing action the ends may be chamfered as shown in Fig. 3C and Fig. 3D on one of the components.

7. ALIGNMENT

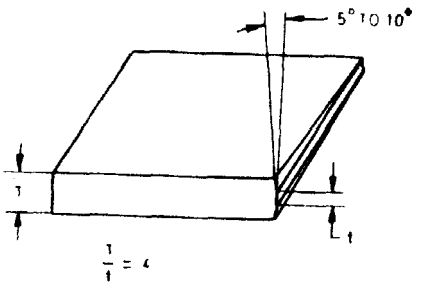
7.1 The sections to be welded should be set in the machine such that they are concentric. To achieve the required alignment, irregularity shall be corrected by either grinding or machining.



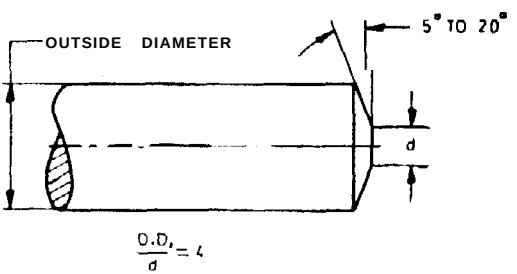
3A Tube



3B Tube for Straight Flashing Only



3C Flat Sheet



3D Round Solid Section

FIG. 3 RECOMMENDED END PREPARATION

When boring is employed, the machined parallel shall be at least the total allowance (sum of negative and positive tolerances) and shall be sufficient to avoid any notch in the weld. The outside diameter is machined concentric over a length to suit the clamping dies.

7.2 Misalignment shall not be permitted for load carrying members or members subjected to shock loads. Any small deviation shall be corrected by grinding without affecting the minimum sectional area requirement.

8. CLEANLINESS

8.1 The ends of the tubes and sections to be welded shall be clean. The material inside and outside the tube in the weld region should be free from rust, paint, greases, swarf or other extraneous materials which are likely to affect weld quality.

No moisture or loose matter should be in the bore of the hollow sections especially while backing gases are to be used.

The outside surface of the sections, where they are clamped, must be free from the above mentioned extraneous materials which are likely to damage the current conducting clamp surfaces. They should be cleaned over the clamping area by grinding or by emery cloth/paper. Metal-to-metal contact at the clamped surfaces must be ensured.

9. WELDING VARIABLES

9.1 Overhang from the Dies — The components should be so clamped that normally the overhang of each is equal. If, however, two differeut materials having varying thermal arc electrical conductivity are to be welded; then the joining should be so positioned as to provide a uniform heat pattern in both the components. The overhang should not be very short as to cause chilling of work or very long as to cause misalignment of the opposing edges among upsetting.

9.2 **Clamping Force** — The clamping force should be just sufficient to prevent movement of work with relation to the clamps during the upsetting operation while at the same time it should not cause any indentation or deformation of the workpieces.

9.3 **Pre-heating** — Prc-heating if required, is normally accomplished and resistance heating, obtained by bringing the components to be welded into contact and separating them while the current is switched on. This operation shall continue until the temperature of the end of the components reaches a value where flashing can commence.

9.4 **Speed of Welding** — The speed of advance of the moving platen and the value of welding current should be regulated to ensure that the flashing

is continuous throughout the cycle and that the welding operation does not freeze up and platen stops moving. The flashing should be smooth, continuous and be maintained until upset takes place. The current shall be maintained until after upset has started.

9.5 **Upsetting** — The value of upset force required to weld steels of different qualities depends on the temperature gradient in the plastic zone and compressive strength of the steel at high temperature.

The upsetting force should be sufficient to:

a) provide forging action of sufficient intensity to unite the plastic weld metal, and

b) squeeze out slag or oxidized material that may be on the abutting surfaces prior to upset.

It should not be so high as to cause distortion of work or excessive expulsion of plastic metal.

10. WELDING PARAMETERS

10.1 The levels of various process variable for flash butt welding depend on material, shape and size of the component to be welded as well as on capacity and capabilities of the machine on which they are to be welded. No definite data can, therefore, be given as 'recommended parameters since welding can be successfully done over a wide range of conditions.

The optimum combination of the levels of various process parameters for a given situation must be decided by experimentation preferably using statistical methods and taking into consideration component shape, size and material, machine, and service requirements.

However, based on the process theory some typical data is given in Appendix A for information which can be translated into the machine parameters in a given situation, to be used as starting conditions for experimentation.

11. EQUIPMENT

11.1 Equipment required for flash butt welding is described in Appendix B.

12. POST-WELD HEAT TREATMENT

12.1 Post-weld heat treatment, if required depending on the material and the section to be welded, shall be specified in the welding procedure. The requirement of the post-weld heat treatment should be as per the application standard or as agreed to between the manufacturer and the purchaser.

If post-weld heat treatment for a limited time is carried out in the flash butt welding machine itself by means of further electrical heating, the procedure shall be agreed to between the purchaser and the manufacturer.

13. WELD PROFILE

13.1 In determining the acceptability of the weld profile as a result of procedure qualification or production control tests, the following features will be taken into account:

a) Height and shape of the upset(s),

b) Notching at the joint,

c) Misalignment of axis, and

d) Spatter.

The acceptance requirements for any of the features will depend on the service conditions of the joint and stipulated by the relevant application standard. If the weld profile in the as welded condition is found unsuitable, operations like machining, grinding, sheering or reaming may be used to get the required weld profile.

14. PROCEDURE QUALIFICATION TESTS

14.1 General — A procedure should be established for each machine, for each size of the sections to be welded and for each material or combination of materials to be used on that machine. The record of the procedure should be based on the appropriate items from the information given in Appendix C.

The optimum settings of the welding variables must be decided experimentally preferably using statistical methods for the given conditions of the machine and the job requirements, using the recommended value as a starting point.

14.2 Number of Tests — When the manufacturer is satisfied that acceptable machine settings have been obtained, a minimum of two welds should be produced using the actual materials to be used in production for inspection by the inspecting authority.

When shaped components like return bends and spirally formed tubes are to be used in production, these shall be used for the tests.

14.3 Frequency of Tests — A procedure shall remain qualified unless there is a change in any of the following parameters:

a) Nominal diameter,

b) Nominal tube thickness,

c) Shape and excess sectional area of sections other than tubes,

d) Material specification,

e) Joint preparation,

f) Machine component, and

g) When there is consistent failure in production test.

14.4 **Heat Treatment** — If heat treatment of production welds (*see* 12) is required, it shall be carried on test welds prior to sectioning. If heat treatment is not required for production welds, no heat treatment shall be carried out on the bend test specimens except in those cases where the bend test specimen does not follow the profile of the former, in which case test specimens shall be given an approved heat treatment (see 12) by agreement with the inspection authority to reduce the hardness and thus permit a uniform bend in the weld area.

14.5 Test Specimens — One or more test welds shall be sectioned to provide at least the following number of test specimens. Thermal cutting shall not be used.

14.5.1 Four bend test specimens shall be taken at equal intervals round the tube (test weld). When shaped components have been used, it may not be possible to take four bend test specimens, in which case the maximum permissible number (not exceeding four) of test welds should be taken.

14.5.2 Four specimens for macro-examination shall be taken at equal intervals around the tube. For small diameter tubes, macro-examinations may be made on prepared edges of each bend test specimen.

14.5.3 Tensile tests, if required as per agreement between the manufacturer and the purchaser, may also be conducted. Tensile test pieces shall be machined so as to have weld in the middle. Dimensions and tolerances of the test piecesand method of testing shall be in accordance with IS : 1521-1972*, IS : 1608-1972†, IS : 1663-1972‡ and IS : 1894-1972§. The tensile strength recorded shall not be less than the specified value of the parent metal. The position of fracture that is weld, heat affected zone or parent metal shall be noted. When fracture occurs in the weld, the appearance, size and the number of defects are determined visually. When defects exist on the fractured surface they shall not exceed an agreed percentage of the initial area of the specimen When non-conventional specimens like flash butt welded reinforcement bars are used for these tests, yield point, elongation and reduction of area are not determined or are only measured to provide additional test data.

*Method for tensile testing of steel wire (*first revision*).

†Method for tensile testing of steel products (*first revision*).

‡Method for tensile testmg of steel sheet and strip of thickness 0·5 mm to 3 mm (*first revision*).

§Method for tensile testing of steel tubes (first *revision*).

14.5.4 Notch toughness tests are made only when specifically required depending on application and as agreed to between the purchaser and the manufacturer and, if necessary, involving inspecting or certifying authority. The type of notch and its position, that is, heat affected zone or weld line shall be as per the agreement.

14.5.5 For solid sections, the number and the location of the test specimens shall be as agreed to between the manufacturer and the purchaser based on the configuration of section, its size and the service requirements.

14.6 Dimensions **of Bend Test Specimens**

14.6.1 Tubes — Each bend test specimen shall consist of a parallel sided strip cut from the welded tube so that the test weld is disposed approximately at the centre. The minimum width of each specimen shall be:

$t + \frac{D}{10}$, when the outside diameter of the tube is less than 50 mm;

and $t + \frac{D}{20}$, when the outside diameter of the tube is 50 mm or greater;

where

t = thickness of the thinner tube, and

D = outside diameter of the tube.

When the D/t ratio is less than 6, the width of the bend test specimens should be given special consideration. It is desirable that the width of the specimen or the sum of the widths of all the test specimens (when more than one are to be made) should be at least 1/3 of the tube circumference (that is covering 1/3 of the total welded area).

The weld shall be dressed flush on the inside and outside surfaces of the specimen and the edges shall be rounded to remove their sharpness. Where tubes of dissimilar thickness are welded, it may bc necessary to dress back the thicker part of the specimen to eliminate any concentration of stress at the weld. The width of the bend test specimen shall be $t + D$ where t and D represent the thickness and diameter of the thinner tube of the 10 dissimilar tubes being flash butt welded.

14.6.2 *Solid Sections* — In case of sections other than tubes, bend test specimens or transverse test shall conform to IS : 3600 (Part 5)-1983* for root and face bend test and to IS : 3600 (Part 6)-1983† for side bend test. If this is not possible, then non-conventional test specimens can be made depending upon shape and size of the sections, and the service

*Method of testing fusion welded joints and weld metal in steel: Part 5 Transverse root bend face test on butt welds (second *revision*).

†Method of testing fusion welded joints and weld metal in steel: Part 6 Transverse side bend test on butt welds (*second revision*).

requirements as agreed to between the manufacturers and the purchasers in such a way that at least 1/3 of the welded area is covered by the width of the bend test specimens.

14.7 **Bend Test and Specimen Examination**

14.7.1 Of the four bend test specimens from each test weld, two shall be tested with the inner surface in tension and two with the outer surface in tension. Methods for bend testing using 'former' shall be as laid down in IS : 3600 (Part 5)-1983* and IS : 3600 (Part 6)-1983†, as appropriate.

Diameter of 'former' to be used for testing the specimens made with various steels are given below along with the required angle of bend:

Material	*Tensile Strength*‡	*For Tubes, Bars or Other Sections*	
	MPa	Diameter of the Mandrel	Angle of Bend
Carbon and low alloy steels	Up to and including 350	2*D*	120
	351 – 440	3*D*	90
	441 – 470	4*D*	90
	Over 470	5*D*	90
High alloy steels including austenitic steels	—	4*D*	90

where ***D*** = outside diameter of the tube or diameter or thickness of the test specimen.

14.7.2 The bend should be without fracture and cracks, although tearing at the edges of the specimen shall not be considered a cause for rejection, if the specimen has bent through the required angle.

If any flaw in the weld zone is made apparent as a result of bending, the requirements of 16 shall apply in determining the acceptability. If bending reveals flaws outside weld zone, this shall not be considered cause for rejection of weld, but as an indication that the material is not suitable.

14.8 **Macro-Examination — The specimen** shall be prepared for examination by polishing and etching in accordance with IS : 3600 (Part 9)-1985§.

*Method of testing of fusion welded joints and weld metal in steel: Part 5 Transverse root bend face test on butt welds (*second revision*).

†Method of testing of fusion welded joints and weld metal in steel: Part 6 Transverse side bend test on butt welds (*second revision*).

‡Actual minimum strength of the material being flash butt welded according to the relevant standard.

§Method of testing of fusion welded joints and weld metal in steel: Part 9 Macro and micro examination.

The requirements under **16** shall apply in determining the acceptability of weld flaws apparent as a result of macro examination. If macro examination reveals flaws in the parent metal, this shall not be considered cause for rejection of the weld but may indicate that the material or batch of material is unsuitable for the particular procedure. In some instances, such as for the detection of breakup in austenitic steels, it is also necessary to carry out micro examination.

14.9 Repeat Tests -- If any one of the above test specimens fails, no repeat tests from the same weldsshall be permitted. Further test weld may be submitted after appropriate remedial action has been taken.

15. PRODUCTION CONTROL TESTS

15.1 Frequency of Tests — They shall be made at the following intervals.

15.1.1 Two test welds at the beginning of each shift or welding period. When machine has not been used for only an hour or less, test welds on commencement of welding are not required.

15.1.2 One test weld at the end of each shift or welding period, whichever is of shorter duration.

15.1.3 Two test welds in the event of any change in machine setting or procedure.

15.2 **Test** Specimens --Each test weld shall be sectioned for four bend test specimens. Heat treatment shall be according to 14.4. Thermal cutting shall not be used. Dimensions of bend test specimen shall be as in 14.6 and the test specimens shall be examined in accordance with 14.7.

15.3 Repeat Tests — **If** there is a failure of bend test specimen from a production control test weld made at the beginning of shift or as a result of change in machine settings, no repeat test from the same test weld shall be permitted but two subsequent welds shall be tested. If they pass the test, production is permitted to continue. If the subsequent specimen fails, the procedure shall be re-qualified before continuing the production.

If there is failure of bend test specimen from the production control test weld made at the end of a shift or welding period, no repeat tests from the same test weld would be permitted, but two additional test welds shall be made and tested or the last two production welds shall be tested. If all the specimens from these additional welds pass, then the production welds made in the relevant shift or welding period may be considered to be satisfactory. If any of these additional specimens fail, further inspection to establish the quality of all the production welds should be undertaken.

16. WELD IMPERFECTIONS

16.1 In the examination of procedure qualification and production control. test specimens, any of the imperfection stated below shall be sufficient cause for rejection.

16.1.1 *Voids* — Cavities, usually with oxidized surfaces.

16.1.2 *Break-up* — Discontinuities occurring in the heat affected zone on either side of weld line.

16.1.3 *Luck of Fusion and Cold Shuts* - Linear discontinuities on the weld line, usually oxidized.

16.1.4 *Inclusions* — Inclusions in particles of non-metallic material in the weld zone, larger than 1·5 mm in length or diameter.

16.2 In the examination of procedure qualification and production control test specimens, the acceptability of the imperfections defined below shall be subject of agreement between the purchaser and the manufacturer.

16.2.1 *Inclusions* — Up to and including 1·5 mm in length or diameter

16.2.2 *Flat Spots*- Characteristic smooth, flat, brittle spot which appear on the fracture faces of mechanical test specimens in partial or complete failure of the test specimen.

The incidence of flat spots shall be kept as low as possible and the welding procedure shall be investigated, if they occur more frequently at a level other than agreed.

16.2.3 *Shelving* (Sleeving) — Misalignment at the weld as a result of one component riding up over the other component during welding, forming a step externally in case of solid sections and tubes and also internally in case of tubes. Thin wall tubes are particularly prone to this type of imperfection.

17. PRODUCT TESTING

17.1 Destructive Testing --- The frequency of destructive testing shall be subject to agreement between the purchaser and the manufacturer, and should take into consideration the following factors:

a) Number of welds made per day per machine,

b) Economic consideration, and

c) Subsequent proof testing during production.

The destructive test shall be carried out in accordance with 15.2.

17.2 **Proof Testing** — A quality control system may be specified with an agreed percentage of components tested by an approved method of proof

testing. The applied loads shall be of a similar nature to those received under service condition.

18. DRESSING AND FINAL INSPECTION

18.1 The external flash shall be dressed to remove crevices and shall be smooth enough to facilitate inspection. The design thickness of the tube shall not be reduced as a result of any dressing. The flash may be removed immediately after the welding operation is over, when the metal is still hot, by means of a special tool.

In general, it is not necessary to remove the upset, but by an agreement between the purchaser and the manufacturer, dressing may be continued until the weld is flush with the surface.

After dressing, it shall be visually examined to establish that the external crevice has been removed. There shall be no evidence of die burns.

18.2 Unless otherwise agreed between the purchaser and the manufacturer, the alignment of tubes should be within the following limits:

a) For tubes of thickness above 4·5 mm, misalignment is not to exceed 10 percent of nominal thickness with a maximum of 0·75 mm; and

b) For tubes of thickness 4·5 mm and less misalignment is not to exceed 5 percent of thickness so as to minimize the risk of shelving.

18.3 Where possible, examination of the bore of the tube shall establish that the upset has been kept to a minimum consistent with a satisfactory weld and does not exceed that agreed at the time of procedure qualification test or as demanded by the application standard.

Spatter in the bore shall not exceed a certain minimum specified in the procedure qualification test.

APPENDIX A

(Clauses 1.1 *and* 10.1)

TYPICAL DATA FOR FLASH BUTT WELDING

A-l. Typical data for setting of the components on the flash butt welding machine for welding is given in Tables 1 and 2 for information.

A-2. Typical data for flash butt welding of low and medium forging strength steel tubes, sheets, and round solid sections is given in Table 3 for information.

TABLE 1 SETTING FOR FLASH BUTT WELDING OF TUBING AND FLAT SHEETS OF LOW AND MEDIUM FORGING STRENGTH STEELS

(Clause A-l; and *Fig.* 1)

Sheets and Tubes									Tubes		
T	*A*	*B*	*C*	*D*	*H*	*J* = *K*	*L* = *M*	Flash Time	*OD*	*S* With Locator	S Without Locator
mm	mm	mm	mm	mm	mm	mm	mm	seconds	mm	mm	mm
025	2·8	1·5	1·3	1·0	0·5	075	1.4	0·40	6·4	9·5	25.5
0·50	5.5	3·0	2·5	2·0	0·9	1·5	2·75	0·80	8·0	9.5	25·5
07.5	8·25	4.5	3.5	3.2	1·3	2.25	4·0	1.25	9.5	9.5	38.0
1·0	11·0	6·0	5·0	4.2	1·7	2.9	5·5	1·75	13·0	9·5	
1·25	13.5	7·1	6·4	5·2	1·9	3.55	6·75	2·25	19.0	13·0	44.0 51·0
1·5	16.0	8·4	7·6	6·1	2·3	4·2	7·9	2.75	25.5	19·0	64.0
1·8	18·0	9.8	8·2	7·1	2 7	4·9	9·1	3·50	38.0	25·5	46.0
2·0	20.0	110	9·5	8·0	3·0	5·5	10·2	4·00	51.0	32.0	Not
2·3	22·5	12·1	10·4	8.8	3·3	6·0	11·25	4.50	64.0	44·5	recommended
2·5	250	13.2	11·4	9'5	3·7	6·6	12.3	5·00	76.0	51·0	without the
2·8	27·0	14·5	125	10.5	4·0	7.25	13.5	5.75	89.0	57·0	use of locator
3·0	29.0	15·5	13·5	11·2	4.3	7.75	145	625	102·0	64·0	
3·3	31·0	16·5	145	12·0	4.5	8.25	15·5	7·00	114.0	70·0	
3·6	33.6	17.8	15.7	13·0	4.8	8.9	16.3	7.75	127.0	70·0	
3.8	35.0	18.5	16.5	13.5	5·0	9.25	17.7	8.50	140.0	76 0	
4·0	37·0	19·5	17·5	142	5·3	9·75	18.7	9·0	152.0	83·0	
4·3	39.0	20.4	18·6	14.8	5.6	10·2	19·6	9.75	165.0	89·0	
4.6	41·0	21.4	18·6	15·5	5·8	10·7	20·6	10.5	178.0	95·0	
4.8	43.0	22·0	20.8	16·0	6·1	11·0	21·5	11.25	191.0	102·0	
5·0	45·0	22.8	21.8	16·5	6.3	11.4	224	12.0	203·0	108.0	
6·4	51·0	25·6	25.4	18·5	7·1	12·8	25.5	16.0	2160	1140	
7·6	57.0	28.5	28·5	20.6	7.9	14.25	28.5	21·0	229.0	121'0	
8·9	62.0	30.8	31·8	22.4	8·4	15·4	31.2	27·0	241.0	127.0	
10·0	67.0	328	34.2	23.6	9·2	164	33.5	33.0	254.0	—	
11·5	70·0	34.4	35·6	24.7	9·7	17.2	35'0	38·0			
13·0	74.0	35.8	38·3	25.9	9·9	17.9	37.0	45.0			
14.0	77.0	37.2	39.8	26.8	10·4	18·6	38.6	50·0			
15·0	80.0	38.3	41.7	27.6	10·7	19.15	39.8	56.0			
16.5	82.0	39.5	43.0	28.6	10·9	19·75	41.2	63·0			
18·0	85·0	41·0	44-6	29·5	11.4	20·5	42.7	70.0			
205	90.0	42·5	47·0	30·7	11·8	21.25	45·0	83.0			
23.0	93.0	44·0	49·0	31.8	12.2	22.0	46.5	97.0			
25·5	96.0	45.8	51·0	33·1	12.7	22.9	48·3	110.0			

NOTE — **Data is** based on welding without me-heating and both pieces have the same welding characteristics.

TABLE 2 SETTINGS FOR FLASH BUTT WELDING OF SOLID ROUND, HEX, SQUARE AND RECTANGULAR BARS OF LOW AND MEDIUM FORGING STRENGTH STEELS

(Clause A-l; and *Fig 2)*

OD	*A*	*B*	*C*	*D*	*H*	*J=K*	*L=M*	FLASH TIME	OD	*S* WITH LOCATOR	*S* WITHOUT LOCATOR
mm	mm	mm	mm	mm	mm	mm	mm	seconds	mm	mm	mm
1·25	2.5	1·25	1·25	1·0	0·25	0.63	1·25	0·4	6·45	9.5	25.4
2·5	4.6	2·1	2·5	1·6	0·5	1.05	2.3	0·75	7.9	9.5	25.4
3.8	6·8	3·0	3·8	2·3	0·75	1·5	3.4	1·15	9·5	9.5	38.0
5·1	9·0	3·8	5·1	2 8	1·0	1·9	4.5	1·5	13·0	9·5	44.5
6·4	11-0	4.6	6·4	3'3	1·25	2·3	5.5	1·9	19.1	13.0	51.0
7·6	13·0	5·4	7·6	3·8	1.5	2·7	6.5	2.25	25.4	19.0	63.5
8·9	15·0	6·4	8·6	4·6	1.75	3·2	7.5	2.75	38.2	25·0	76·0
10·2	17.4	7.2	10.2	5·2	2·0	3.65	8.7	3.25	51·0	320	Not
11·4	19.6	8·2	11·4	5·9	2·3	4.1	9.8	3.75	63·5	44.5	recom-
13.0	21.6	8·9	12.6	6.4	2·5	4.45	10·8	4.25	76.0	51·0	mended
1 40	23.8	10·8	14 0	7·1	2·8	4.9	12.0	5·0	88.5	57 0	without
1 50	26.0	11.0	15.2	7·8	3 05	5·4	13·0	5·5	102.0	63.5	the use
16.5	28·0	11·5	16.5	8.3	3.2	5.7	14·0	6.75	114.0	70.0	of
18.0	30·0	12.2	17.8	8.7	3.4	6·1	15·0	7.5	127.0	70·0	locator
19·0	32.0	13·0	19·0	9·5	3'5	6.5	16·0	8.25	140·0	76·5	
20·0	340	13·7	20·3	10'1	3.55	6.9	17·0	9·0	152·0	82.6	
21·5	36.0	145	21.5	10·8	3.7	7·25	18.0	9.75	165.0	89.0	
23.0	38·2	15·2	22.8	11·4	3·8	7·6	19·0	10.5	178.0	95·5	
240	40·0	16.0	24·1	12.0	4.05	8·0	20.0	11.75	190'0	102.0	
25.5	42.2	17.0	25·4	12·7	4·1	8.4	21·0	13·0	203·0	108·0	
27.0	44.2	17.5	26·5	13·3	4.2	8·8	22.0	14·75	216·0	114.0	
28.0	46.2	18·0	28·0	14·0	4·3	9·15	23.0	16.5	229·0	121.0	
29.0	48.3	19.0	29·2	14·6	4·45	9·5	24.0	18.25	241·0	127·0	
30·0	50·4	20·0	30·5	15·2	4.65	10·0	25.0	20.0	254.0	—	
32.0	52·4	20.6	31·4	15·9	4.7	10·3	26.2	22.5			
33.0	54.4	21.3	33·0	16·5	4·8	10·7	27.2	25·0			
35.5	58.4	22.9	35·5	17·8	5·1	11.4	29.2	30·0			
38·0	625	24.4	38.1	19'1	5·3	12.2	31.2	38·0			

(*Continued*)

TABLE 2 SETTINGS FOR FLASH BUTT WELDING OF SOLID ROUND, HEX, SQUARE AND RECTANGULAR BARS OF LOW AND MEDIUM FORGING STRENGTH STEELS —*Contd*

OD	*A*	*B*	*C*	*D*	*H*	*J*=*K*	*L*=*M*	FLASH TIME
mm	mm	mm	mm	mm	mm	mm	mm	seconds
40·5	66·5 70·5	26·0	40·5	20·4	5·6	12·9	33·2	45·0
43.0		27·4	43.1	21.6	5·8	12·7 14·5	35·3	54·0
45·5	74%	29.0	45·8	22.9	6·1	15·3	37·3	63·0
48.0	79.8	30·5	48.3	241	6.35		39.3	75·0
50.0	82·0	32.0	50·8	25·4	6.6	16·0	41.4	90.0

NOTE 1 — Data is based on welding without pre-heating and both pieces having the same welding characteristics.

NOTE 2 — The above values apply only where the ratio of maximum to minimum cross-sectional dimension does not exceed 1·5.

OD = external diameter for circular section,

or

= smallest dimension for the other sections.

TABLE 3 DATA ON WELDING PARAMETERS FOR LOW AND MEDIUM FORGING STRENGTH STEELS

(Clause A-2)

CLASS OF STEEL PRODUCT	WALL THICKNESS/ DIAMETER	AREA OF SECTION	FLASHING VOLTAGE	AVERAGE FLASHING CURRENT	FLASHING POWER	*Max* POWER	FLASHING TIME	UPSETTING LOAD
	mm	mm²	volts	kA	kVA	kVA	seconds	tonnes
Tubes and sheets	0·5	25·0	2.3	0·8	2·0	3·0	0·8	0·3
	1·0	50.0	3.2	1·0	4·0	6·0	1·75	0·5
	1·5	100.0	4·0	1·7	8·0	10.0	2.75	0·8
	2·0	240·0 160·0	4·4 4.2	2·5	10·0	25.0 18·0	4·0 .625	1·0
	3·0					35·0	9·0.	1·5
	4·0	320.0	5-o	3.5	16·0	50·0	12·0	2·5
	5·0	400.0	6·0	4.8	20·0			3·2
Round and other solid sections	10·0	78·5	2·2	1·0	7·0	10·0	3.25	0·5
	14·0 12·0	113·0 154·0	3.5 3.8	2·0 4·0	7·0 · 8·0	14-o 12.0	3.8 5·0	1·0
	15·0	177.0	4·0	6·0	10·0	20·0	5·5	2·0 2·8
	18·0	254·0	4.5	8·0	12·0	25·0	7·5	3.2
	20·0	314.0	5·0	12.0	15·0	30.0	9·0	3·6
	25·0	500.0	5·3	15·0	20.0	50.0	10·0	4·0
	35·0	1 000·0	6·2	25.0	40·0	120.0	16·0	8·0
	50.0	2 000·0	7·8	35·0	100.0	320.0	30·0	16·0

APPENDIX B

(*Clauses* 1.1 *and* 11.1)

EQUIPMENT

B-1. Most of the modern equipments for flash butt welding are automatic or semi-automatic. These equipments have to be very accurate in controlling the various parameters.

The machine should be equipped with an automatic control gear which after the workpieces, have been clamped in the dies takes control of the machine out of the hands of the operator and performs at least the following cycle of operations in the sequence given below:

a) Closes the electrical circuits and brings the workpieces into initiai contact,

b) Establishes the pre-heating cycle (where applicable),

c) Establishes and maintains the flashing cycle for the desired period of time or length of stroke,

d) Upsets the work to complete the weld, and

e) Cuts off the current to the workpieces at the commencement of upset.

B-2. The other automatic operations that may be included in theequipment are:

a) unclamping of the die to remove workpiece,

b) switch on the supply of the backing gas to inside of tubes for a present period of purging time before the operation is started, and

c) maintain the pressure of the backing gas until the upsetting has finished.

B-3. Clamping is usually done by means of hydraulically operated devices.

The clamping and upsetting forces, pre-heating and flashingcurrents, the speed of platen approach, the duration of preheating and flashing and the purging period and pressure of backing gas should be capable of being varied over a sufficient range to ensure that optimum welding conditions can be obtained. Dials and scales should be provided to present the parameters before welding starts.

B-4. Flash guards may be provided for safety of operator from the flashes flowing out. If they are used they should be placed at such a distance from the clamped components as to minimize the possibility of particles, thrown off during flashing period getting trapped into the weld. Before any weld is made, the die faces should be free of spatter, contact faces clean of oil, grease, etc, air blast should not be used as it can force metallic dust into slides, bearings, internal parts of machine and cause danger to persons near the machines.

APPENDIX C

(Clause 14.1)

TYPICAL INFORMATION TO APPEAR ON A WELDING PROCEDURE SHEET FOR FLASH WELDING

1. Welding procedure number
2. Related specification and/or drawing number
3. Material to be welded; specification number or composition
4. Metallurgical condition of weld
5. Welding machine number
6. Preparation of ends of work and clamping surfaces of work
7. Details of backing gases; type and pressure
8. Initial distance from dies
9. Work overhang from fixed die
10. Work overhang from moving die
11. Clamping force
12. Upset force
13. Flashing allowance
14. Flashing time
15. Welding current or transformer tapping
16. Upset current time
17. Free or limited upset; if the later, length of upset travel required
18. Welding sequence
19. Routine for making test welds
20. Particulars of surface finish of weld
21. Pre-heating procedure
22. Post weld heat treatment procedure, if any

(Continued *from page 2*)

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